# Flame arresters

## Preventing the spread of fires and explosions in equipment that contains flammable gases and vapours


**This is a free-to-download, web-friendly version of HSG158 (First edition, published 1996). This version has been adapted for online use from HSE's current printed version.**

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This book provides guidance on how flame arresters can help prevent the spread of fires and explosions from pipes and vessels containing flammable vapour or gas. It describes the different categories and types of flame arrester, the criteria for selection, and maintenance requirements.

The guidance is aimed primarily at managers, supervisors and technical workers responsible for the safety of plant containing flammable vapour or gas. It may also be of interest to trade organisations or associations who may wish to use the guidance as a basis for more specific guidance for their own members.

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This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

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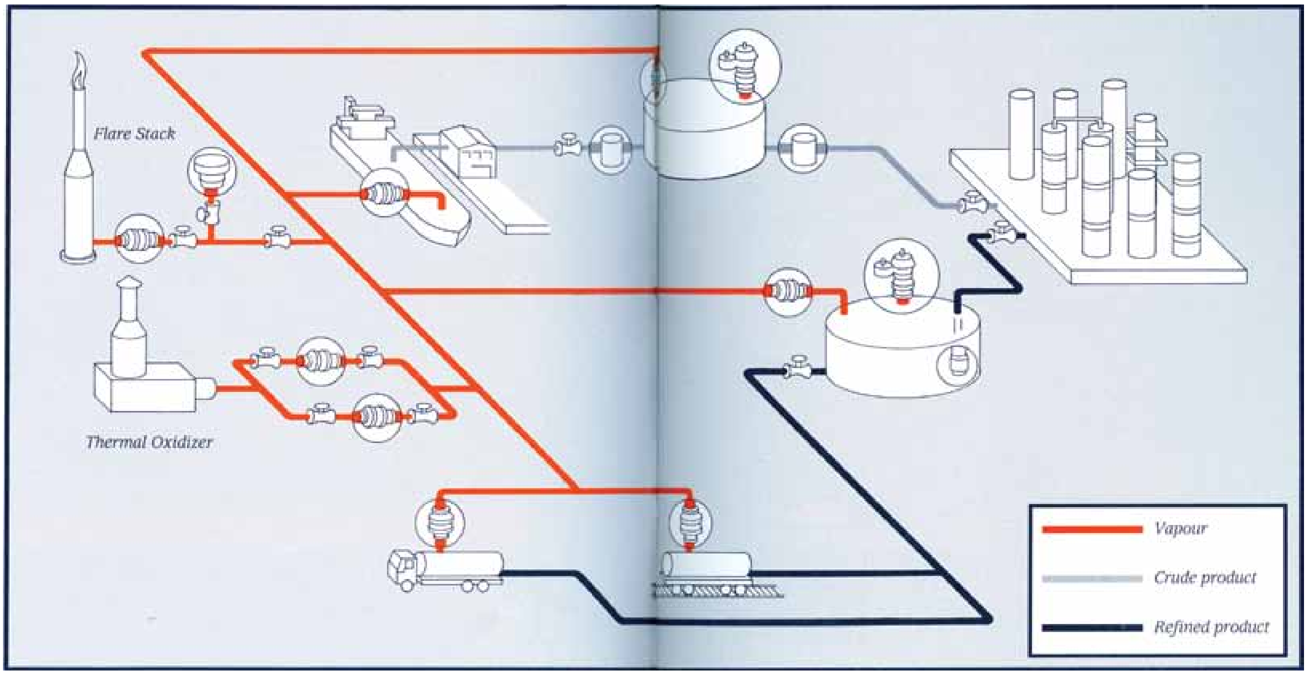
# Introduction

1 This booklet provides information and advice on how flame arresters can reduce risks by preventing the spread of fire and explosion in vessels and pipes containing flammable atmospheres.

2 Flame arresters are commonly located in vent pipes from storage tanks, in pipes carrying vapours or gases to flare stacks, incinerators and furnaces, and in vapour recovery and balancing systems. They act as a type of barrier between pieces of equipment, preventing the spread of flame. Typical locations for flame arresters are illustrated in Figure 1.

3 Flame arresters are used where there are permanent sources of ignition such as incinerators and flare stacks to prevent flashback if a flammable atmosphere develops in the vapour feedlines. They are also used to protect plant and equipment, containing flammable vapours from potential sources of ignition. Any piece of equipment or process which is capable of producing sparks, flames or hot surfaces is a potential source of ignition. Where vapours are vented to atmosphere, they may be ignited by lightning or other external sources of ignition. Flame arresters are used to prevent flashback from the atmosphere into the equipment.

**Figure 1** Typical locations for flame arresters



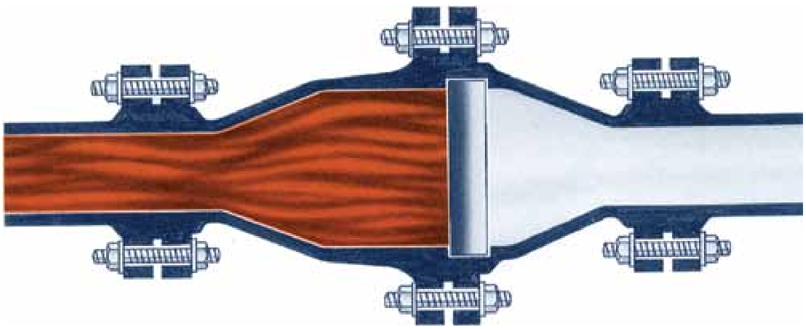
4 Most flame arresters consist of an element and its housing (Figure 2). The element is a permeable matrix made up of narrow passages or openings. Gas or vapour can flow through these apertures. In the event of a fire or explosion, if burning gas enters the matrix it is subdivided and quickly cooled on the cold surface of the element. The flame is extinguished and the gases are cooled sufficiently to prevent re-ignition as they emerge from the element.

5 This booklet describes the different categories and types of flame arrester, the criteria for selection and the maintenance requirements. It replaces HSE's booklet HSG11, *Flame arresters and explosion relief*. It is aimed at managers, supervisors and technical workers responsible for the safety of plant containing flammable vapour or gas.

6 Flame arresters are also used for welding and cutting equipment, and for diesel engines used in potentially flammable atmospheres. These uses are outside the scope of this booklet. Information is available in other publications,[1,2] if required.

7 Where a British Standard is quoted, any other national or international standard that provides an equivalent level of safety is acceptable. Harmonised European Standards that bear the preface BS EN may supersede some British Standards, and these are equally acceptable, when published.

**Figure 2** Sketch of flame arrester



# Legal requirements

8 The Dangerous Substances and Explosives Atmospheres Regulations 2002[3] (DSEAR) require that precautions should be taken to reduce the risk of fires and explosions, where flammable liquids or gases are stored or processed. The publication *Design of plant, equipment and workplaces*[3] advises on the use of mitigation measures such as flame arresters to prevent the propagation of fires and explosions in interconnected plant and equipment. It also advises that vent pipes from plant containing flammable, highly flammable or extremely flammable liquids, required for normal operation, should discharge to a safe place and normally be provided with a flame arrester.

9 There are also general duties under health and safety law which are relevant. The three main pieces of legislation are outlined below. Further information is given in Appendix 1. A glossary of terms is provided in Appendix 4.

10 The Health and Safety at Work etc Act 1974[4] requires employers to provide and maintain safe systems of work. They are also required to take all reasonable precautions to ensure the health and safety of employees and anybody else who could be affected by the work activity. Employees and the self-employed also have a legal duty to take care of their own and other people's health and safety.

11 Under the Management of Health and Safety at Work Regulations 1999,[5,6] every employer has a duty to carry out an assessment of the risks to the health and safety of employees and of anyone who may be affected by the work activity. This is so that the necessary preventive and protective measures can be applied.

12 The Provision and Use of Work Equipment Regulations 1998[7] aim to ensure safe work equipment is provided and is safely used. They include general duties covering the selection of suitable equipment, maintenance, information, instructions and training.

# Selecting a flame arrester

13 A flame arrester is a protective device; it will not prevent an incident from happening. Measures should be taken, where practicable, to prevent the flammable atmospheres forming by using containment, process control or ventilation. Ignition sources should be controlled.

14 When deciding whether a flame arrester may be needed, an assessment should be carried out to identify:

- where flammable atmospheres may arise;
- where there are ignition sources or potential ignition sources;
- whether fire can spread between pieces of equipment;
- the consequences of an ignition.

15 Flame arresters are designed, tested and installed to meet particular operating conditions. If there is a mismatch between the arrester and its environment, it may fail. To ensure that an effective flame arrester is selected, it is essential that the conditions in which it will be used are specified carefully and accurately. This section provides information on the parameters which need to be considered when selecting a flame arrester.

16 There are many different designs of flame arresters and many different manufacturers. Appendix 2 describes the various types of flame arrester available and outlines their range of application. Some alternatives to flame arresters are also mentioned.

17 Generally, new flame arresters should meet the requirements of the European Standard BS EN 12874: 2001 *Flame arresters. Performance requirements, test methods and limits for use*.[8] Flame arresters already in use may have been supplied to other national and international standards which provide an equivalent level of safety.[9] Appendix 3 provides details of these standards.

18 If there is more than one ignition source, an arrester should be selected to meet the most severe conditions predicted. Depending on the circumstances, it may be necessary to use more than one arrester or an arrester that is effective in both directions.

19 Although flame arresters prevent fires and explosions propagating through plant, they do not provide explosion relief. It may be necessary to provide pressure relief[10] or strengthen equipment. Thermocouples may also be fitted to arresters to detect overheating and trigger automatic shut-off valves.

20 The factors to be considered when specifying a flame arrester include the:

- category;
- run-up distance;
- vapour or gas involved;
- temperature and pressure;
- acceptable pressure drop across the arrester;
- possibility of blockage or contamination;
- arrangements for cleaning and maintenance;
- materials of construction;
- possibility of stabilised burning on the element;
- possibility of oxygen enrichment.

Each of these factors is now described in more detail.

## Category

21 There are three categories of flame arrester:

- an end-of-line deflagration arrester;
- an in-line deflagration arrester; and
- a detonation arrester.

Typical locations for in-line and end-of-line arresters are shown in Figure 1, page 4.

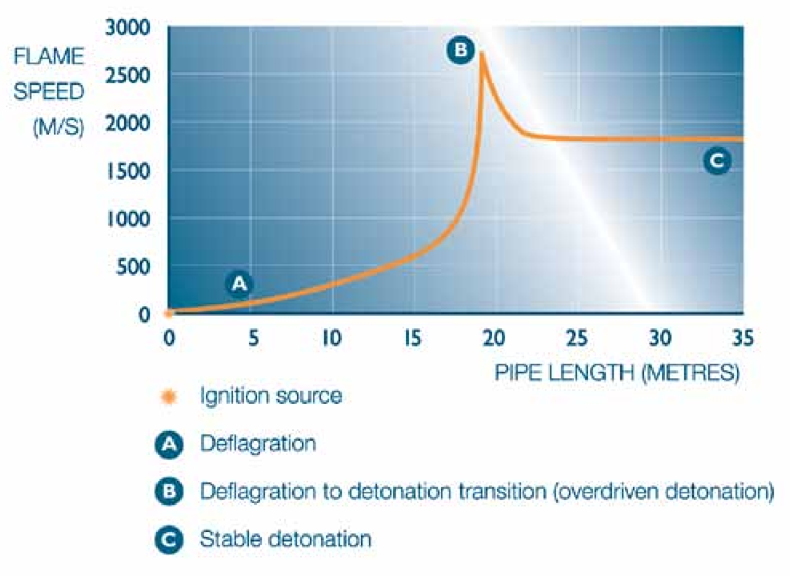
22 End-of-line deflagration arresters are installed at the end of vent pipes on process vessels, storage tanks and transport containers. If the vented vapours are ignited, perhaps by lightning, the arrester will prevent the fire spreading from the atmosphere to the inside of the vessel.

23 In-line deflagration arresters are mounted in pipelines to prevent a flame being transmitted along the pipe. They are placed as close as possible to any likely ignition source to avoid detonations. Typical applications include protection for the fuel/air supply to a burner, or use in a vent where there is a length of pipe between the arrester and the point of discharge to the atmosphere.

24 Detonation arresters are used as in-line arresters where a detonation is possible. For example, they may be used to protect tanks, vessels or process pipes containing flammable vapour from potential ignition sources such as fans, compressors, incinerators and flare stacks.

25 The terms 'deflagration' and 'detonation' relate to flame speed. If a flame travels at less than the speed of sound it is called a deflagration. If it travels above the speed of sound it is termed a detonation and is accompanied by high pressure effects. As a flame travels along a pipe it accelerates rapidly (Figure 3). If the pipe is long enough the flame will eventually reach detonation condition with a speed of about 2000 m/s and explosion pressure in excess of 20 bar. The rate of acceleration of the flame is also increased by bends, T-junctions, obstacles and changes in the cross section of the pipe.

**Figure 3** Graph representing acceleration of flame to detonation conditions




26 Deflagration arresters are designed to stop deflagrations, but are generally not strong enough to withstand a detonation. Detonation arresters have considerable strength and are normally designed to stop both deflagrations and detonations. The most severe event that an arrester may face is an overdriven detonation. This may happen during a transition from a fast deflagration to a detonation. Under such circumstances the detonation becomes unstable and achieves much higher flame speeds and explosion pressures than a stable detonation, placing a greater demand on the flame arrester. If an overdriven detonation is possible, a detonation arrester which provides protection against both stable and overdriven detonations will be required.

## Run-up distance

27 The run-up distance is the length of pipework between the potential ignition source and the arrester. Flame speed increases with run-up distance as shown in Figure 3 and as described in paragraphs 21 to 26. Consequently, flame arresters are fitted to minimise run-up distances. This means minimising the length of pipework between the possible ignition source and the flame arrester. For example, end-of-line arresters for pipe lines venting to atmosphere are fitted as close to the end of the vent line as possible, to provide protection against ignition sources from outside such as lightning.

28 A maximum run-up distance is specified for each deflagration element, based on the results of practical tests. If the run-up distance is exceeded there is a danger of the arrester not being able to stop the flame or withstand the overpressure.

29 Bends, obstructions and rough surfaces cause turbulence and acceleration of the flame. The increase in flame speed is difficult to predict depending on many factors such as the run-up distance to the bend, the length of pipe after the bend and the number of bends. Deflagration arresters only provide protection against flames travelling at subsonic speeds and at low explosion pressures. If there is any doubt about the effectiveness of a deflagration arrester, a detonation arrester should be used.

## Vapour or gas

30 Flame arresters are classified according to gas groupings.[11,12] There are four gas groups: I, IIA, IIB, IIC. Methane is the only gas in Group I. It is usually combined with Group IIA which covers commonly used gases such as propane or petroleum products. Group IIB covers more reactive gases such as ethylene. Group IIC covers the most reactive gases such as hydrogen and acetylene. Under identical conditions of pipe length and diameter the flame speeds that result at the flame arrester increase progressively from gases in Group I to Group IIC.

31 If more than one gas or vapour is being used, select a flame arrester suitable for the most reactive gas.

## The temperature and pressure of the gas or vapour

32 The specification of a flame arrester also depends on operating temperatures and pressures. Increases in temperature or pressure above those specified by the supplier may result in deflagration arresters failing. A similar failure could result if the arrester is too close to a burner flame or other hot surface and overheats. In those situations a detonation arrester may be more appropriate.

33 In addition, bends and obstructions downstream of the arrester may also cause an increase in pressure at the arrester and impair its effectiveness.

## The pressure drop across the arrester

34 The main disadvantage of flame arresters is that because they have a fine structure they introduce a resistance to flow. Equipment downstream may be unable to operate or may operate erratically if the pressure drop is too high. The resistance to flow can be minimised by using an arrester element and associated housing that has a diameter greater than the pipe diameter. However, if the expansion piece leading to the arrester housing is too divergent it may lead to increased turbulence and therefore accelerated flames.

35 As flame arresters reduce the flow rate of gases and vapours in pipes they are not fitted in emergency venting systems unless the rate of venting is sufficient to compensate for the presence of the arrester. If there is a concern about the possibility of ignition in emergency vent systems it may be better to provide an inert gas purge.

## Blockage or contamination

36 Materials that polymerise or need heating to maintain them in the vapour state may solidify in the flame arrester, causing blockages. It is generally not appropriate to use flame arresters with these substances. Other methods such as inerting or explosion suppression may be more suitable.

37 Blockage may also be caused by condensate and particulate matter. Some flame arresters are designed or can be modified to incorporate condensate drains. These will need emptying at appropriate intervals. End-of-line arresters may be fitted with a weather cowl to protect against rain and airborne dust.

38 It may be useful to monitor and record the pressure differential across the arrester as this will give an early indication of contamination or blockage. It is important that the monitoring device does not provide a flame path around the arrester.

39 If a pre-filter is used upstream of the arrester, it may avoid or reduce blockage. Trace heating may also help in this respect. Some caution may be needed to ensure that these measures do not impair the effectiveness of the arrester.

## Cleaning and maintenance

40 When selecting the location for an arrester, it is important to consider its accessibility for cleaning and maintenance purposes. Some arresters are designed to allow easy removal and maintenance.

## Materials of construction

41 Flame arrester elements are normally made of stainless steel but are also available in specialised materials such as hastelloy, monel or nickel. The housings are usually made of carbon steel. It is important that the elements of the flame arrester are compatible with the operating environment to limit corrosion, blockage or other damage.

## Stabilised burning

42 Stabilised burning is when a flame is not extinguished but continues to burn at the flame arrester element. In this situation the flame arrester may overheat until it is no longer able to prevent the flame from propagating through to the other side.

43 If stabilised burning is a possibility, this may be detected using a thermocouple linked to an alarm system which may also trigger automatic cut-off of the vapour or gas supply. The flame arrester should have a safe burning time greater than the response time of the emergency shut-down system. The safe burning time is the period a flame arrester can endure stabilised burning without flame transmission.

44 If, for operational reasons, it is not desirable to stop the flow, flame arresters with minimum safe burning times of up to two hours are available. Methods to quench the flame such as injecting steam through an inlet port may be required.

## Oxygen enrichment

45 Gases or vapours mixed with oxygen or oxygen enriched air are more reactive than mixtures with air and are more likely to detonate. This needs to be taken into account when specifying a flame arrester.

## Flame arrester specification sheet

46 The supplier will provide a specification or information sheet giving a full description of the flame arrester, including its recommended application, any limitations, installation and maintenance procedures.

# Maintaining the performance of flame arresters

## Inspection and maintenance

47 Health and safety law[4] requires that plant and equipment is maintained in a safe condition. It is essential that flame arresters are well maintained. They should be covered by a programme of regular inspection and maintenance so that they continue to be effective. They should be inspected for damage or distortion following any known or suspected deflagration or detonation.

48 Keep records of the specification of each arrester, its location and its inspection and maintenance history. Include relevant information in maintenance and operating procedures.

49 The main maintenance problem is that flame arresters behave as filters. They have a tendency to block up, so require regular cleaning. Monitoring and recording the pressure drop across the element will indicate fouling of the arrester and a suitable cleaning frequency can be determined. Alternatively, it may be possible to determine such frequency by visual inspection, particularly during the initial period of use.

50 Suitable cleaning methods include the use of solvents, water, steam, compressed air or ultrasonics. Care is needed to ensure that the cleaning method is compatible with the arrester in terms of the materials of construction and its overall robustness. Flame arresters should not be cleaned by pushing sharp objects into them because this will damage the flame arrester element.

51 If the element is damaged, its effectiveness will be impaired and a replacement may be necessary. Carefully ensure that the replacement is of the right specification and that it is fitted correctly, in line with the manufacturer's recommendations. Elements are often marked with the specification numbers, which may be used as a further check.

**The effectiveness of a flame arrester may be impaired or destroyed if:**

- it is incorrectly installed;
- it is incorrectly assembled;
- the wrong components are used;
- it is damaged or distorted;
- it is blocked or contaminated;
- process conditions are changed;
- plant modifications are made.

## Plant and process modifications

52 Plant and process modifications can reduce the effectiveness of the flame arrester. Check the flame arrester specification to see whether the arrester needs to be changed.

53 There may also be an impact on the maintenance requirements for the arrester. Review the frequency of inspection, cleaning and maintenance after such modifications.

## Training

54 The provision of adequate training is a requirement of several pieces of legislation.[1,5,7] It is essential that all workers involved with the plant design, operation and maintenance are aware of the function of flame arresters and the importance of maintaining them in a clean, undamaged condition. A typical training programme will include the:

- importance of correct assembly and installation;
- effects of damage and distortion;
- effects of blockage or contamination;
- effects of changing process conditions or making plant modifications.

# Appendix 1 Legal requirements

## Health and Safety at Work etc Act 1974 (HSW Act)

1 The HSW Act is concerned with securing the health, safety and welfare of people at work, and with protecting people who are not at work from risks to their health and safety arising from work activities. The HSW Act and its relevant statutory provisions are used to control the keeping and use of explosive or highly flammable substances and are concerned with precautions against the outbreak of fire in all work activities. The HSW Act is enforced either by HSE or by local authorities, as determined by the Health and Safety (Enforcing Authority) Regulations 1989.[13] Further advice on these matters is obtainable from HSE's local area offices or the local authority.

## The Management of Health and Safety at Work Regulations 1999

2 These Regulations require all employers and the self-employed to assess the risks to workers and others who may be affected by their work activities so that they can decide upon the appropriate measures that need to be taken to fulfil their statutory obligations. These Regulations also require an assessment to determine the requirements for appropriate health and safety arrangements, health surveillance, emergency planning, provision of information and training. An Approved Code of Practice *Management of health and safety at work*[5] gives guidance on the provisions of these Regulations. An HSE leaflet *Five steps to risk assessment*[6] gives simple general advice on the steps involved in the risk assessment process.

## The Dangerous Substances and Explosives Atmospheres Regulations 2002

3 These Regulations are concerned with protection against risks from fire, explosion and similar events arising from dangerous substances used or present in the workplace. The publication *Design of plant, equipment and workplaces*[3] advises on the use of mitigation measures such as flame arresters to prevent the propagation of fires and explosions in interconnected plant and equipment. It also advises that vent pipes from plant containing flammable, highly flammable or extremely flammable liquids, required for normal operation, should discharge to a safe place and normally be provided with a flame arrester.

## The Provision and Use of Work Equipment Regulations 1998

4 Under these Regulations employers must ensure that:

- suitable equipment is provided for the jobs involved;
- information and instruction are adequate;
- equipment is maintained in good working order and repair;
- training is provided for operators and supervisors;
- equipment is safeguarded to prevent risks from mechanical and other specific hazards;
- equipment is provided with appropriate and effective controls;
- maintenance is carried out safely.

Guidance on these Regulations is available in an HSE publication, *Safe use of work equipment. Provision and Use of Work Equipment Regulations 1998.*[7]

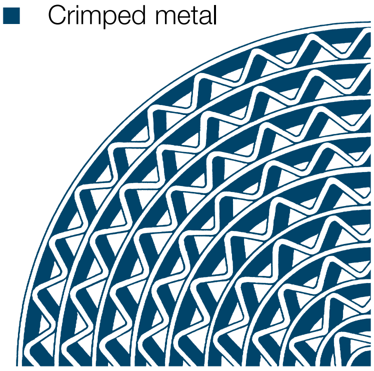
## Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 1996

5 These Regulations[14] describe measures to prevent ignition by equipment and apply both to electrical and non-electrical equipment and protective systems. They apply to all equipment intended for use in potentially explosive atmospheres.

# Appendix 2 Types of flame arrester and alternatives

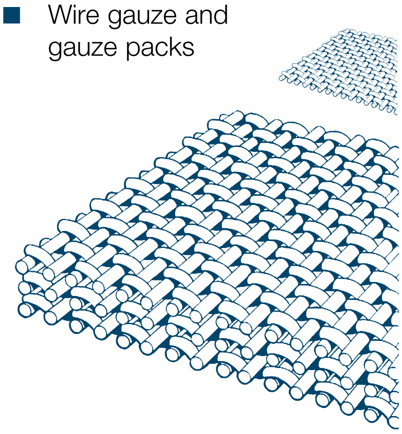
Flame arrester elements may be constructed in different ways. The majority have a solid matrix but some designs use water or other liquids. This section gives a brief description of the different construction types currently available. Other methods to prevent flame propagation such as fast acting valves and suppression are also outlined.

- Crimped metal



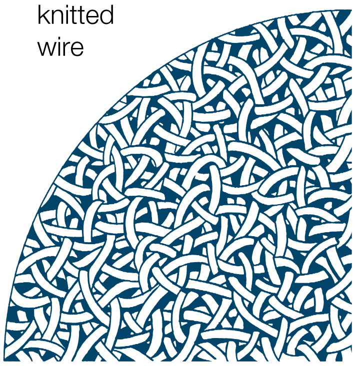
Crimped metal arresters may be manufactured from alternate layers of crimped and uncrimped metal ribbon to produce a range of different sized triangular cells, according to the degree of hazard. They are robust and can be manufactured to within close tolerances. Because usually less than 25% of the face of the arrester is obstructed by the ribbon, the resistance to the flow of gas is minimised. They are supplied as both deflagration arresters and detonation arresters.

- Wire gauze and gauze packs



These arresters are in the form of single gauzes or a series or pack of gauzes. They are manufactured in a way which ensures that the aperture size is carefully controlled. Single gauzes are generally used only on the ends of vent pipes such as for underground petrol tanks. Gauze packs are robust with efficient flame quenching properties and flow capabilities. They are generally supplied as deflagration arresters only.

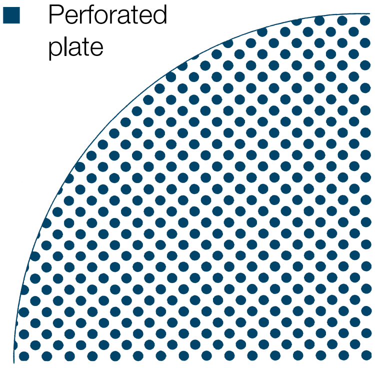
- Compressed or knitted wire



These arresters are in the form of wire or a strip of wire mesh wound onto a roll and compressed into a cylindrical housing. They have a random structure with apertures that depend on the amount of compression applied. They are generally supplied as deflagration arresters only.

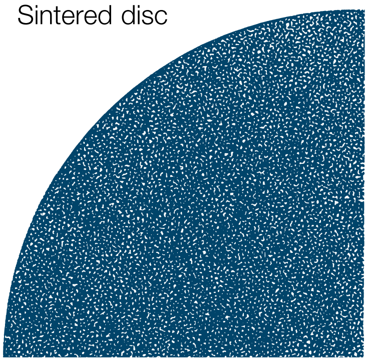
Note: The above drawings are not to scale

- Perforated plate



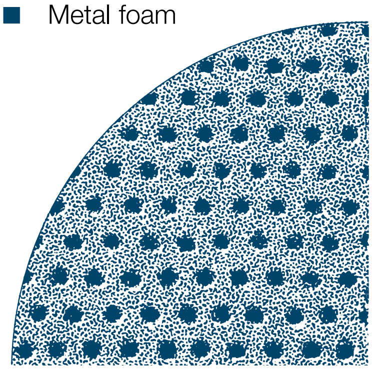
The element consists of one or more layers of metal plates perforated with circular holes. They may have greater mechanical strength than elements of similar construction type but the proportion of free area for gas flow may be lower.

- Sintered disc



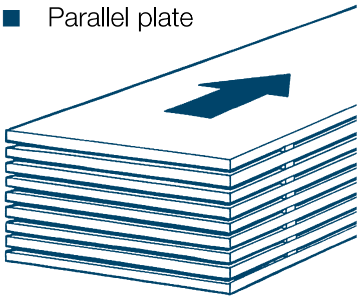
These contain discs or cylinders of sintered metal or other material. The apertures can be made very small so these arresters are able to quench very violent explosions provided that they are given sufficient mechanical strength. However, these arresters have a high resistance to gas flow and are therefore normally used where flow resistance is unimportant and the gases are clean. They are often used to protect gases discharged from storage cylinders and in some types of flammable gas analysers and detectors.

- Metal foam



Flame arresters can be made from a metal foam produced by plating a polyurethane foam. Elements can be made in various pore sizes and are capable of meeting the most severe conditions. They also have low resistance to gas flow.

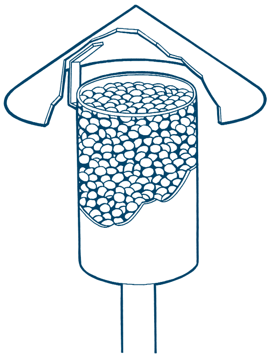
- Parallel plate



These arresters are constructed of unperforated metal plates or rings arranged edgewise to the gas flow. They are separated from each other by a small spacer and can be made in a range of sizes. They are very robust and are able to withstand the most severe conditions. They are easily dismantled for cleaning and consequently are used in the exhaust systems of internal combustion engines. One type used in this situation is partially self-cleaning so can be used for longer periods without removal.

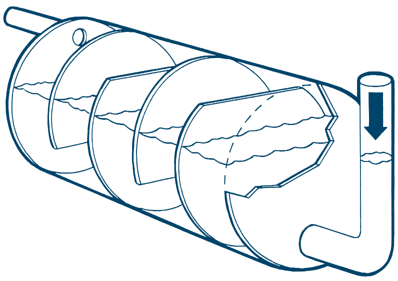
Note: The above drawings are not to scale

- Packed tower, metal spheres and pebble box



These arresters consist of a tower or other container filled with small pebbles, Raschig rings, metal spheres or some other pellet type material. The size of the apertures depends on the sizes of the pellets which are packed tightly within the container to prevent movement. They can be made to withstand severe explosions. They can be easily assembled and dismantled for cleaning purposes but may have a high resistance to flow.

- Hydraulic or liquid seal



In this type of arrester, the gas stream is passed through a liquid (often water) which breaks up the gas into discrete bubbles. Constant monitoring is required to ensure that liquid levels are maintained – liquid may be lost through evaporation or leakage. Also, the gas is wetted by the liquid, so problems may arise downstream of condensation or corrosion.

## Alternatives

The following are alternatives to the static flame arresters already described. They are sometimes referred to as dynamic flame arresters, as they have moving parts.

- High velocity vent valve

These may be fitted to the outlet of vent pipes on storage tanks or marine cargo tankers for petroleum products. The valve needs a positive pressure to open and the emerging jet of vapour produced during operation is at high velocity so that if it ignites the high velocity prevents the flame propagating past the valve.

- Fast acting valve/slam shut valve

This may be mounted in a pipeline. As the flame travels down the pipeline it is detected by a sensor that sends a signal, to close the valve before the flame reaches it. This system does not involve a pressure drop.

- Suppression

A flame sensor may also be used to trigger a suppression or inerting system which then extinguishes the flame. Suppressants may be used with fast acting valves.

Note: The above drawings are not to scale

# Appendix 3 Standards for flame arresters

1 The European Standard BS EN 12874: 2001 *Flame arresters. Performance requirements, test methods and limits for use* contains procedures for testing the effectiveness of flame arresters.[8] This supersedes the British Standard BS 7244:1990 *Flame arresters for general use* which is currently obsolescent and may be withdrawn.[9] Other standards which may be encountered include those developed by the International Maritime Organisation[15] and the United States Coastguard.[16]

# Appendix 4 Glossary of terms

**deflagration:** Explosion propagation at subsonic velocity which may be confined (propagating within an enclosure with a speed influenced by the enclosure), or unconfined (propagating freely through an unobstructed atmosphere).

**deflagration flame arrester:** A flame arrester designed to prevent a deflagration from being transmitted.

**detonation:** Explosion propagating at or above sonic velocity and characterised by a shock wave coupled to a combustion wave.

**detonation (stable):** A detonation travelling with a velocity equal to the velocity of sound in the burnt gas (Chapman-Jouguet velocity).

**detonation (unstable or overdriven):** In some circumstances, such as during the transition from a fast deflagration to a detonation, the detonation may become unstable so that higher velocities and pressures are achieved compared to a stable detonation. This type of flame is known as an overdriven detonation, and it places a greater demand on the performance of a flame arrester.

**detonation flame arrester:** A flame arrester designed to prevent a detonation from being transmitted.

**endurance burning:** This is the property of a flame arrester to endure stabilised burning without flame transmission, under specified test conditions.

**explosion:** Abrupt oxidation reaction producing an increase in temperature or pressure, or both simultaneously.

**flame arrester:** A device to be fitted to the opening of an enclosure or to the connecting pipework of a system of enclosures and whose intended function is to allow flow but prevent flames from being transmitted.

**flame arrester element:** The portion of a flame arrester whose main function is to prevent flame transmission.

**flame arrester housing:** The portion of a flame arrester whose main function is to provide a suitable enclosure for the flame arrester element, and to allow mechanical connections to other systems.

**flammable atmosphere:** A concentration of flammable gas or vapour in air that falls between the upper and lower explosion limits. It may also be referred to as an explosive mixture or a flammable concentration.

**flare stack:** A flare system is used to burn unwanted flammable gases in a safe manner. Discharge of the combustion products to atmosphere is via a flare stack.

**hazard:** Something that has potential to cause harm to people, property or the environment.

**inerting:** To render incapable of combustion.

**lower explosion limit (LEL):** The minimum concentration of gas or vapour in air below which the propagation of a flame will not occur in the presence of an ignition source. It may also be referred to as the lower flammable limit or the lower explosive limit.

**risk:** The likelihood that a hazard will lead to harm within a specified period or in specified circumstances.

**risk assessment:** The process of identifying the hazards present (whether arising from work or other factors) and the people likely to be affected by those hazards. It also involves an evaluation of the extent of the risks involved, taking into account precautions which have already been taken.

**run-up distance:** The distance between the potential ignition source and the flame arrester element. A maximum run-up distance is specified for deflagration arresters. The presence of bends and obstructions can be considered to increase the run-up distance.

**safe burning time:** The period of stabilised burning without flames being transmitted.

**stabilised burning:** Steady burning of a flame stabilised at or close to the flame arrester element.

**upper explosive limit (UEL):** The maximum concentration of gas or vapour in air above which the propagation of a flame will not occur in the presence of an ignition source. It may also be referred to as the upper flammable limit or the upper explosive limit.

# Appendix 5 References

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# Further information

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